**ELECTROCHEMISTRY**

SCH 4U

Unit Test

**ANSWER KEY TOTAL / 40**

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| **KNOWLEDGE and UNDERSTANDING**  **10 marks** (15 / 1.5) |

**All multiple-choice questions are 1 mark each 11 marks**

1. A galvanic cell is

a) a chemical system that produces an electric current through a spontaneous redox reaction.

b) a chemical system that uses an electric current to drive a non-spontaneous redox reaction.

c) a flow of electrons in a circuit (= electrochemistry)

d) a chemical system is which a solute conducts a current in an aqueous solution ( = electrolyte)

e) a chemical system in which a compound breaks down into elements or simpler compounds ( = decomposition reaction)

2. Rusting is

1. A decomposition reaction
2. A combustion reaction
3. A redox reaction
4. A neutralization reaction
5. A double displacement reaction

3. Primary batteries contain...

1. Rechargeable cells
2. No cells
3. Fuel cells
4. Electrolytic cells
5. Galvanic cells

4. In both a galvanic cell and an electrolytic cell,

1. Reduction occurs at the cathode
2. The cell potential is positive
3. The overall reaction is spontaneous
4. An external voltage is required
5. Chemical energy is converted to electrical energy

Following questions from <http://www.sparknotes.com/chemistry/electrochemistry/review/quiz.html>

5. What is the oxidation state of gold in Au(CN)4-?

1. 3
2. -1
3. 0
4. 4

6. Which of the following reactions is **NOT** a redox reaction?

1. Na + Cl ---> NaCl
2. H2O2 --> HO2 + H+
3. Ni2+ + Fe ---> Fe2+ + Ni
4. NaOH + HCl ---> NaCl + H2O

7. Which of the following terms best describes CH4 in the following reaction?



1. oxidized
2. oxidizing agent
3. hydrolyzed
4. reduced

8. Which half-reaction takes place at the anode?

1. The one with the greater reduction potential
2. The one that transfers the most number of electrons
3. The reduction
4. The oxidation

9. What is a faraday?

1. A unit of current
2. A unit of energy
3. A unit of charge
4. A mole of electrons

10. Which of the following is **NOT** produced during the electrolysis of water?

1. Electricity
2. Acid
3. Hydrogen
4. Oxygen

11. At which electrode is H2 in the electrolysis of water?

1. The anode
2. The electrode connected to the negative side of the battery
3. The cathode
4. Cannot be determined with the given information

**Indicate whether each statement is true or false in the following five (5) questions. Each question is worth 1 mark. 4 marks**

\_\_\_\_T\_\_\_\_ 12. Electrolytic cells are based on non-spontaneous reactions and have a positive cell potential difference.

\_\_\_\_F\_\_\_\_ 13. Cathodes are always positive in redox reactions.

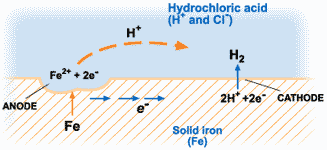
\_\_\_\_T\_\_\_\_ 14. In a redox reaction the number of total number of electrons lost equals the number of electrons gained.

\_\_\_\_T\_\_\_\_ 15. A strong oxidizing agent has a great capacity to lose electrons.

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| **THINKING and INVESTIGATION**  **10 marks** (20/2) |

**NOTE: CHOOSE 2 of the 3 questions**

16. Take a look at this picture **10 marks**



1. What terminology is used for this common chemical reaction? **(1 mark)**

Corrosion

1. Write out the full chemical reaction that is occurring. **(2 marks)**

Reduction reaction: Fe(s)→ Fe2+(aq) + 2e-

Oxidation reaction: H2O(l) + ½O2 (g) + 2e-→ 2OH-(aq)

1. Give an example of when/where this chemical reaction would occur. **(1 mark)**

Rusting on a car fender

1. Give 2 reasons why this commonly happens to iron (Fe). **(1 mark)**

Wear and tear or a dent in the fender exposes iron to water, air and salt

1. What are two ways of preventing this chemical reaction from occurring? Give a brief explanation of how each method works to prevent this chemical reaction. **(5 marks)**

There are a number of ways to slow down corrosion, if not prevent it.

* Prevent oxygen and water from contacting the metal. This can be accomplished by paint, grease, plastic, or other methods of covering the metal.
* Cathodic protection - pieces of zinc or magnesium metal may be bolted to the surface of iron. Both Zn and Mg are oxidized more readily than Fe, which results in those metals being oxidized thus sparing and protecting the iron. Propeller shafts of speedboats are often protected this way. Anode rods in water heaters also work this way (they are often called "sacrificial anodes"). Galvanized nails - nails coated with the more reactive zinc - provide yet another example.
* Metal alloys - an alloy is a mixture of metals, or a mixture of a nonmetal with a metal. An alloy such as stainless steel (chromium is added to steel - a mixture of iron and other elements such as carbon - to make stainless steel) is highly resistant to corrosion but can be prohibitively expensive

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| 17. Following are two reduction half – reactions for the half-cells of a voltaic cell. **10 marks**  Determine the overall cell reaction and the standard potential. Write the cell chemistry using cell notation with vertical lines separating components.  I2 (s) + 2e- → 2 I-(aq); E0= 0.5355 V  Fe2+(aq) + 2e- → Fe (s); E0= - 0.447 V |

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| Your Solution:  A: *Analysis of the Problem*  The half reaction with the lower potential will proceed as an oxidation  Known:  E0cell = E0 reduction- E0 oxidation  Unknown = E0 cell =?  *Solution:*  The iodine half reaction has higher potential and will proceed as reduction in the forward direction. Rewrite the equations.  I2 (s) + ~~2e~~- → 2 I-(aq) (reduction half cell reaction)  Fe(s) → Fe2+(aq) + ~~2e-~~ (oxidation half cell reaction)  I2 (s) + Fe(s) → Fe2+(aq) + 2 I-(aq) (overall cell reaction)  Now, E0cell = E0 reduction- E0 oxidation = 0.5355 – (-0.447) = +0.983 V   |  |  | | --- | --- | | Oxidation half cel reactn | Reducton half cell reaction | | Reactant | Product | Reactant | Product | | Fe | Fe2+ | I2 | I- | |

18. In an electrolytic cell, how many grams of Cu could be plated out of a CuSO4 solution at a current of 5.00 A for 2.00 min? (*F* = 96500 C/mol). Show your work. **10 marks**

a. 318 g

b. 0.395 g

c. 0.329 x 10-3 g

d. 0.198 g

e. 5.31 g

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| Step 1: Write the reduction half-reaction equation | Cu 2+ + 2 e- → Cu |
| Step 2: Convert time to seconds. | 2.00 min = 120 secs |
| Step 3: Calculate the charge. | Q = I x t  = 5.00 A x 120 secs  = 600 Coulombs |
| Step 4: Convert charge to moles. | n = Q / F  = 600 C / 96 500 C /mol = 0.0062 moles |
| Step 5: Apply mole ratio. | N Cu = 0.0062 moles x 1mol Cu / 2 mol e- = 0.0031 mol  Step 6: Convert moles to mass.  0.0031 mol X 63.546 g /mol = 0.1969 g  = 0.198 g |

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| **COMMUNICATION**  **10 marks** (15/1.5) |

19. Jerome, your classmate is having trouble understanding the reduction and oxidation. How you would you clearly explain this concept to Jerome? Feel free to use acronyms, diagrams, concept maps, examples etc. to explain. **5 marks**

An **oxidation** reaction describes a loss of electrons, while a **reduction** reaction occurs

when there is a gain of electrons. These reactions always occur in tandem and hence

are referred to as **REDOX** reactions.

**Identifying Oxidation and Reduction Reactions**

One easy way of remembering REDOX reactions is the expression

“Leo the Lion says Ger”

Meaning:

**L**ose **E**lectrons **O**xidation, **G**ain **E**lectrons, **R**eduction

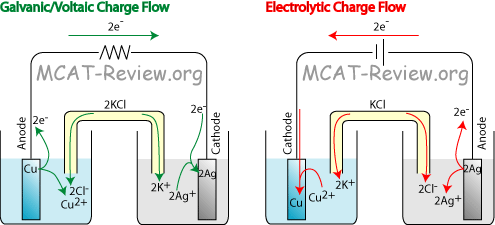
Losing electrons causes an increase in the oxidation number (i.e. 0  +2)

Gaining electrons causes a decrease in the oxidation number (i.e. +2 0)

The total number of electrons gained in a reaction must equal the total number of

electrons lost.

20. Draw a diagram of an electrolytic cell and galvanic cell and explain the difference between both. Be sure to include flow of electron, electrical potential **10 marks**



**Galvanic cell** contains a **spontaneous** reaction with electrons flowing from a higher potential to a lower potential, thereby generating electrical energy.

**Electrolytic cell** uses energy to move electrons from a lower potential energy to a higher potential energy. The overall reaction in an electrolytic cell is **non-spontaneous**, and requires an external source of energy to occur.

Because of the external voltage of the electrolytic cell, the electrodes do not have the same polarities (charge) in electrolytic and galvanic cells.

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| **APPLICATION**  **10 marks** (20/2) |

**NOTE: CHOOSE either 21 or 22**

21. **The Automobile Lead Storage Battery: 10 marks**

i) What is the function of the acid in the lead-acid storage battery used in cars?

The acid serves as the electrolyte.

The net reaction when a lead acid battery is discharged is the following:

PbO2 + Pb + 2 H2SO4→ 2 PbSO4 + 2 H20

ii) Lead is both oxidized and reduced in the net reaction. Write the redox equation for each reaction. Hint: There is only a gain of 2 electrons by the lead.

(oxidized) Pb → Pb2+ + 2e-

(reduced) For PbO2 : Pb 4+→ Pb + 2e- → Pb2+

iii) Write the reaction for the formation of lead sulphate. Your equation should show what happens to the Pb2+.

Pb2+ + SO4 2-→ PbSO4

Lead sulphate is formed at both electrodes when the lead acid battery is discharged.

iv) Why does leaving on the lights or radio for too long with the engine off make the car battery go dead?

Leaving on the lights or radio for too long with the engine off make the car battery go dead because it is the engine that recharges the battery as the car runs.

v) What should you do if you have a dead car battery and why?

You should hook up your battery to another car battery which is not dead. Let the charged car battery engine run. Your car battery will be recharge because electricity from the charged battery supplies the dead battery by passing the dead battery

22. **Electrolysis – HAIR REMOVAL**

Electrolysis can be used to remove unwanted hair from the skin. **10 marks**

**The hair is first coated with a layer of gel containing ions in solution.**

**The positive electrode is connected to a patch to the skin.**

**The negative electrode is connected to the hair. Electricity flows through the gel and causes electrolysis of the body fluid around the hair follicle.**



1. Metal wires conduct electricity to the electrodes.

Explain how metals conduct electricity.

Metallic bonds are made from a lattice of ions in a 'cloud' of free electrons. These free electrons are responsible for the ability of metals to

1. conduct electricity
2. conduct heat especially well.
3. Explain why the gel containing ions in solution can conduct electricity.

The free ions in the gel acts as an electrolyte

(c) The body fluid is a solution that contains sodium chloride. The electricity causes the electrolysis of a small amount of this solution.

This solution contains hydrogen ions that move to the negative electrode.

(i) The half equation represents the reaction at the negative electrode.

2H+ + 2e– → H2

Explain why this reaction is a reduction.

Hydrogen gains two electrons

Complete the half equation for the reaction at the positive electrode.

2Cl – → 2e- Cl2